Paper ID: 150

A Review on Wireless Sensor Networks and Object Detection Methods in Military Applications

NWAGN Nanayakkara [1#], WMKS Ilmini[2], and NT Jayathilake[3]

[1,2]2Department of Computer Science, Faculty of Computing, General Sir John Kotelawela Defence University, Colombo, Sri Lanka

[3] Institiute of Technology, University of Moratuwa, (ITUN), Colombo, Sri Lanka

[#] <37-cs-5966@kdu.ac.lk>

Abstract— *Object detection and tracking is a very useful technique in today's world when it comes to military activities as well as daily activities. If a battlefield is considered, there are places which are inaccessible for the humans. In such instances, it is easy to monitor the location remotely. Also, using an automated monitoring system reduces the life risk of the soldiers deployed in the specific location. This review study is conducted with the aim of identifying the most suitable technologies and sensors to be used in the wireless sensor network along with the image processing and machine learning techniques available for object detection. This review study is carried out under two main topics as, wireless sensor network based military applications and object tracking and detection. The systematic literature review was conducted to identify the most appropriate set of research papers. Then the selected papers were reviewed and the most important facts needed to identify the solution was identified. The network topology of the systems is, ad-hoc topology. ATmega182L, ATmega 2560 are the mainly used type of microcontrollers for the previously developed systems. PIR sensor, CMOS camera module are the mostly used equipment for the process of acquiring images. Image processing techniques are used for object detection and classification purpose. This review paper concludes that the best type of microcontroller is ATmega, CMOS LM9628 to use as image sensor and the protocol for the WSN can be ZigBee.*

Keywords— **Image Processing, Military, Unmanned Air Vehicle, Wireless Sensor Network (WSN)**

I. INTRODUCTION

Human tracking and monitoring have become popular research topics with wearable sensor networks and computer vision techniques. In a territory, there are a lot of human actions by both the friendly forces and the enemy forces. Not a territory, consider a jungle. There are be several types of actions associated. Some actions might be the actions of humans, and other actions are carried out by animals and other objects. Tracking and monitoring these actions are not an easy task. If it is a battlefield, there is a huge threat for the person who is deployed for

the above task. Sometimes, there are places which are inaccessible to humans. Monitoring those places is not an easy task. There must be some type of mechanism to overcome the difficulties faced in such situations. To overcome these problems, Wireless Sensor Networks (WSNs) can be used as a technological measure.

A WSN is made up of connecting several sensor nodes. A sensor node is a collection of a power supply, sensor, processing unit and a wireless communication module. One of the main designing strategies of WSN is it should be able to work for a longer period without failure as the power supply capability is limited [1]. The sensor nodes in the WSN are cost-effective while the physical size is small, and the communication range is also small. A sensor node is a collection of four sub-systems: power supply subsystem, sensing subsystem, communication subsystem and computation subsystem [2]. WSNs are used not only in the military sector. They are used in industries, for agriculture, for medical purposes and many more. A special type of a WSN is a soldier worn systems. The network is made up by providing a sensor node for each soldier. That node has the ability to track the movements the actions of the soldier. It is extremely helpful when studying the patterns of soldiers and also it will facilitate to understand the status of the specific soldier who is having it. Some other applications of WSNs in the military sector are, Self-healing Land Mines, Sniper Detection and Localization, Perimeter Protection and many more. The research challenges of WSNs are of two types as, Engineering Challenges and requirements for the future developments [3]. There are some areas, especially in battlefields which are not accessible for humans even to deploy the sensor nodes. A special mechanism called the Unmanned Air Vehicle (UAV) is used. The UAV will deploy the sensor node in random positions and they will arrange the network independently [4].

Another application of technology in the military is the monitoring of suspicious activities. There is a requirement to observe the moving objects, mainly human beings. Then it is needed to analyze their behavior and provide data in real time. For that purpose, it is needed to examine and study similar systems and research work carried out by other researches. WSN can only give the sensed data to the relevant authorities. But the sensed data must be analyzed to extract the relevant information. Different sensors embedded with IR cameras will provide the captured images. Machine learning techniques, different classifying algorithms and image processing is needed for the analysis of captured images. Convolutional neural networks are the main machine learning technique used [5]. The purpose of this systematic literature review is to identify the most suitable and the cost effective methodology to implement a system to monitor humans. The aim of this research work is to analyze the best technologies or techniques that can be used to detect objects using existing research applications and to study the sensors and algorithms needed for this purpose. Also, it is needed to analyze the input methods, image processing techniques, accuracy and also the outcomes. Further the most appropriate and cost-effective technology for the WSN will also be identified.

The paper is in 5 sections as, Introduction, Literature Review, Methodology, discussion and conclusion. The introduction section gives a brief description of the research work. The methodology is about how this research work was conducted. The Discussion provides reasoning about the literature and the conclusion provides the final outcomes.

II. LITERATURE REVIEW

This section includes a comprehensive review on the ten most important research works identified when carrying out this study. The factors like, input methods, image processing techniques, algorithms, accuracy and outcomes are examined under two main topics as, 'WSN in the Field of Military' and 'Object Detection and Monitoring.' The technology, algorithms, inputs, outcomes and accuracy will be examined under the two topics.

Wireless Sensor networks in the Field of Military

The paper [4] aims to implement an energy efficient WSN system to optimize the scheduling of nodes and to implement it for military applications. The requirements for such systems are effectiveness, sensitivity which is controllable, durability and ability to detect the signals effectively. It is stated that the radio frequency signal detection will be accurate if there is active communication between the nodes. The components needed for the proposed system are, XBee Series 1 [6] module, PIR motion sensor and an Arduino MEGA 2560 [4]. Out of several algorithms and protocols available to access the lifetime of batteries, optimum node scheduling algorithm is used to increase the lifetime of batteries. It is stated that the lifetime is extended by 10.2% from the algorithm. Main reason for choosing ATmega 2560 is, it works well with the selected protocol XBee. The protocol XBee is used because it consumes low battery as well as it is cost effective. The author has concluded that, in future, it is planned to use a camera recorder in order to send real-time notifications using SMS if something suspicious is detected.

Madhu and Sreekumar [7] conduct a study on how to prevent attacks in a WSN which is deployed in the military field. The authors used an approach which is based on a cluster to prevent attacks. The developed system consists of a toy car with a micaz mote. Mote is a module which is capable of navigating some device with the help of GPS and other technologies. GPS is used to locate the current location and the vehicle can send messages directly to the nearest sink node. The mote is responsible to navigate the vehicle. The motes are deployed randomly in the field and a base station is deployed to monitor the nodes. The authors have found that denial of service attack, sybil attack, node replication attacks and privacy attacks as some of the attacks associated with WSNs. The research introduced an unmanned vehicles as the motes to make the system more secure. The camera module, and the sensors are attached to the vehicle the battery power and the computation power of the driver mote is equal to that of the base station as sensitive data is passed. The system is clustered and each cluster has a head to control the communication between nodes. TinyOS is used for the system as it consumes low power and less resources. The navigation system was developed by using GPS and also without using GPS. They concluded that the GPS based localizations algorithms were the most accurate even though it is a bit costly.

The paper [8] aims to propose a multi-hop WSN model based on a cluster tree with the cluster head being optimized along with the nodes to meet the requirements of tactical military. It is stated that a WSN can be used for the protection of friendly forces as well as to analyze the movements and the behavior of soldiers using soldier worn WSNs. Once the sensor nodes are deployed, they have the ability to organize by themselves and to maintain the connectivity autonomously. From the four types of WSN models, the authors propose multi-hop based clustering model [8] because it is scalable and consumes only a small amount of energy. The nodes will self-organize themselves according to the cluster tree

topology. The authors conclude that, the proposed system is a multi-hop WSN based on a cluster tree with a cluster head with optimized head election.

The paper [9] by Michael, Tuchs, Kster and Graeme aims study about both practical and theoretical aspects of WSN. It is stated that the main requirements of WSN in the field of military are, to protect the forces and to monitor the activities of specific locations. Some assumptions like cost, size and weight regarding the sensor nodes are made when proposing algorithms. There are three generations of sensor nodes as first, second and third. The authors have identified three main classes of WSN as node-centric, position-centric and data-centric. Bluetooth, ZigBee and WLAN are the three routing protocols available for WSNs. Out of the available sensors, multi-modal sensors are used because the detection of critical instances are very reliable. Also, the authors have mentioned some of the attacks associated with WSNs as, eavesdropping, spoofing, denial of Services and Physical compromise.

The paper [1] written by Zhi-Yan, Sheng-Zhuo and Ming-Zeng aims to design and develop an image sensor node for a WSN. A node of the proposed system will include a CMOS image sensor, processor, RF module, image acquisition unit, power supply and memory. The authors have identified that the node should have more memory and processing power, high communication bandwidth at real-time, distributed processing and also it should be energy efficient. Out of CCD and CMOS image sensors, authors propose the CMOS image sensor as it acquires only a small amount of power. LM9628 was used as the sensor because the performance is high and only a less amount of power is consumed. Adopted RF module is Chipcon's CC100. SAMSUNG's S3C44B0X RISC based processor is used as the processor for the proposed system. It is concluded that LeGall wavelet transform was used as transform core for image compression with the goal of saving power. Out of the several algorithms for image compression, SPECK is the best because of low complexity and low memory requirement.

Object Detection and Monitoring

The paper [5] written by Chaitanya and Zuber aims to design a WSN which can be used in military. In the proposed system, the sensor nodes will be deployed in a random manner using a helicopter or an Unmanned Aerial Vehicle. The Deep learning Neural network is used to track the objects. Multiple objects can be tracked by the Convolutional Neural Network (CNN). The two staged of the CNN are classification and feature extraction. An IR or a PIR sensor is used to capture the images. If something suspicious is detected, the camera module will trigger and capture the image. Two object detection algorithms, CNN and YOLOv3 will be used to detect the objects in the image. It is concluded that the PIR sensor is used to detect suspicious objects and once detected, a SMS alert through the GSM module will be sent to the relevant authorities.

The paper [10] written by Yuliadi, Afaf and Agil aims to develop an algorithm to calculate the walking speed of a person. OpenCV library is used for image processing while HAAR Classifier algorithm is used to detect the pedestrians. The algorithm developed to estimate the speed of walking consists of 4 steps as, image acquisition, human detection, calculation of speed and output. Out of the two algorithms HAAR Cascade-Classifier and Histogram Oriented Gradients (HOG) it is stated that both has the ability to detect humans accurately but HAAR is more stable than HOG when it comes different light conditions as dark, dim or bright. Further it is stated that, both algorithms are unable to differentiate whether the images are coincided or not. It is concluded that out of the two available algorithms the HAAR Cascade-Classifier algorithm is the best because it has the ability to detect and differentiate both non-human and human objects accurately in both dim and bright light outdoors and indoors.

The paper [11] written by Balaji and Karthikeyan aims to review the various types of object detection and tracking. The main components of video analysis in object tracking are, object detection, classification and frame to frame object tracking. The two main object detection methods used are Frame Difference Method, Background Subtraction Method and Optical Flow. Further, background subtraction has two approaches as Recursive Algorithm and Non-Recursive algorithm. Object Classification has several types such as Motion based, Texture based, Shape based, and Color based classification. The researchers state that texture based, and color-based methods are the most accurate while the accuracy of other two are medium. Point tracking, Kernel Tracking and Silhouette Tracking are the three types of object tracking. Finally, it is concluded that the background subtraction method is the easiest as it provides complete details of the object compared to other two methods. The kernel-based tracking will need detection only once the object is first appeared on the screen But point tracking will need detection in every frame.

Shipra and Sachin [12] carried out a survey to find out about image processing techniques in object tracking. Objects are represented by points, geometric shapes, skeletal models, multiple view object recognition and

templates. Even though most of the algorithms are based on HIS color, but the classification accuracy will be high if RGB color is used. Background subtraction will be the best of the segmentation models as it includes frame differencing, median filtering, linear predictive filter and nonparametric model. Active contour-based tracking minimizes the complexity of computation compared to region-based method. Further it is stated that, errors of segmentation and tracking difficulties arise when tracking complex objects. Tensor voting is used to handle multiple structures.

The paper [13] written by Aghaei, Gandelli, Grimaccia, Leva and Zich developed an algorithm which is used for IR image analysis along with an algorithm to detect the affected part of PV modules using matlab software. The experimental setup was made using a UAV which is possible of flying over the Lab for IR image capturing with the help of a thermo-camera. It is stated that processing of digital images will be very beneficial when detecting the defects in the PV modules. The developed algorithm is capable of carrying out an analysis with the intention of identifying the defects of the images captured. The first step of this process is the conversion of the image which is in RGB mode to Gray scale. Then the image filtering process is carried out and the Gaussian filter will be deployed for this purpose as it is capable to reduce the noise as well as the other irrelevant details of the IR image. Then the binary image which is capable to provide a percentage of the damage caused is obtained. Further the Laplacian model will be extracted in order to determine the failures and the defects of the PV module accurately. The reason for the transformation of the image to gray scale it to get a clear and a image with a uniform color distribution. The idea of using the binary image is to differentiate the parts which are hot and cold. The authors mention that the developed algorithm has the ability to process an IR image and differentiate the healthy portion from the defected portion successfully. The algorithm is also capable of finding out whether the identification is really a defect or any satin which is result of the thermo vision process. The authors justify that the proposed algorithm has the ability of detecting and determine the percentage which is gone under degradation along with the boundary area associated with the module.

III. METHODOLOGY

This section will provide an overview of how this research activity was carried out. The main part of conducting this research was carrying out the systematic literature survey to find out the main techniques and other important factors considered when implementing already developed systems. After identifying the research gap, research work related to the identified field of study was selected. This chapter will mainly explain how the literature review was carried out by reviewing existing systems to find out the most appropriate solution for the detected problem. Figure 1 will give a general idea how this review was conducted.

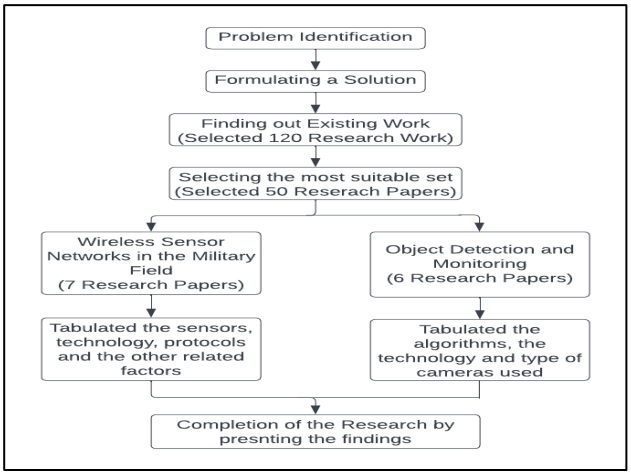

Figure 1. Methodology

The first step in carrying out this review was to identify the problem correctly. The identified problem can be stated as, there is a huge threat to the lives of the soldiers on the battlefield. In the battlefield, sometimes, deaths are occurring because of not the war. They occur when the soldiers are deployed to monitor the enemies. To reduce this rate and to identify the real problem, some of the military officers were contacted. The officers were given the question of what their opinion if an automated monitoring system is introduced and will they think that it will be a successful and a useful implementation. The opinion of the officers is that it would be more beneficial if a system was deployed to track and monitor the behavior of suspicious people which can be used in a hybrid mode along with the physical security meshes and techniques. When carrying out the initial study, factors like present monitoring strategies, current system of communication and the available technologies were considered.

After considering all these initial factors, then the solution for this problem was formulated. The best solution to be taken to track and monitor the actions in a territory, implementing a WSN with image processing techniques to analyze the captured objects.

After identifying the solution for the problem, sources like, IEEE [14], Springer [15], ResearchGate [16], Semantic Scholar [17] and Google Scholar [18] were used to find out for the existing and related research activities carried out by other researchers. Both research

papers and review papers were considered when searching for the literature. As the initial results, 120 research papers were taken. There were research papers related to the military field as well as non-military object detection and object tracking systems. Out of the 120 papers, 50 papers were selected as the most suitable set of the papers. The abstracts were read and criteria like, the year of publication, number of citations and author biographies were examined when selecting the set of 50 research papers.

The selected papers were divided into two main groups as, Military based WSNs and Object detection. There were object detection research activities carried out using image processing and Artificial Intelligence. When grouping the papers, papers were arranged according to the number of citations and according to the year of publication. 6 research papers were selected as the most suitable papers under the topic of 'Wireless Sensor Networks in the Military Field.' Abstracts and discussions were reviewed when selecting these papers. 7 research papers were selected by reading the abstracts and discussions for the topic of 'Object Detection and Monitoring.'

From the 6 selected papers based on WSN and the military field, the types of sensors, technologies and the protocols respect to each research paper was tabulated and compared against each other. The same procedure was carried out for the 7 papers related to object detection. The algorithms used, datasets, cameras used for image acquisition and the techniques were tabulated and a comparison was carried out against one another.

After reviewing of the obtained research papers were finalized, the literature review of the paper was completed. 10 papers were selected by analyzing the tabulated data and a comprehensive review for each paper was written by mentioning the most important information. The software which is called Zotero [19] was used to highlight and review the research papers. The final comparison of the papers is included in the discussion and the conclusion will provide the most suitable approach to make the Wireless Sensor Network. The most appropriate algorithm, technique and the camera module for object detection is also justified in the conclusion section of this paper.

IV. DISCUSSION

This section provides a comprehensive discussion about the facts identified from the papers reviewed in the literature review section. Table 1 provides a summary of the important facts identified. The title of the paper, main technologies, other technologies and the reviews are interpreted in the table.

Table 1. Summary of Reviewed Papers

Paper	Main Area	Main Technologies / Components	Other Technologies / Components	Remarks
[4]	WSN	ZigBee technology PIR Motion sensor Arduino Mega 2560 XBEE Series 1	Random Backoff Sleep Protocol (RBSP)	Camera recorder will be used along with PIR sensor and an SMS will be sent through XBEE as soon as motion is detected. Internet will be used to send the image as data rate of ZigBee is low.
[7]	WSN	TinyOS. Unmanned Vehicle	Micaz Mote	GPS based localization algorithms were the most accurate in navigation compared to non-GPS based algorithms. But, the cost for GPS based algorithms is comparatively high.
[8]	WSN	Multi-hop-based clustering model	Cluster tree topology	Out of the four WSN topologies, multi-hop based clustering module is used as it is scalable and consumes low energy.
[9]	WSN	Three main routing protocols	Different attacks	Propose that formats for sensor data like textual information or images will have a good market.
[1]	WSN	CMOS Image Sensor node FGPA chip for image processing module	Shape-Adapted Discrete Welvet Transformation (SADWT) LeGall Welvet Transformation Structure based coding algorithms (EZW, SPIHT, SPECK)	Out of CCD and CMOS image sensor nodes, CMOs image sensor node is used because of low power consumption. SPECK is used as require only a less amount of dynamic memory and computational complexity is also low.
[5]	Neural Network	ad-hoc network Unmanned Arial Vehicles	YOLOv3 CNN.	PIR sensor is capable to detect objects clearly. GSM module sends SMS alerts in real time Deep-learning based CNN provides best results for single and multiple objects both in daylight and nightlight.
[10]	Image Processing	Open CV library HAAR-Cascade Classifier	Histogram of Oriented Gradient (HOG)	Out of the two human detecting algorithms, HAAR Cascade Classifier is proposed as the best because it has the capability to detect human and non-human single and multiple objects indoor and outdoor in both bright and dim light. But it has no ability to detect in dark light conditions.
[11]	Image Processing	Object Detection (Frame Difference, Background Subtraction, Optical Flow) Object Classification (Motion-based, Texture-based, Shape-based, Color-based) Object Tracking (Point, Kernel, Silhouette)	-	The background subtraction method is the easiest as it provides complete details regarding the detected object. Texture-based and Color-based classification methods are the most accurate methods available. Kernel and contour based tracking needs detection only when object is appeared first but point tracking needs to detect the object every time.
[12]	Image Processing	Kalman filter Motion segmentation Object tracking Classification of objects	HSI colour scheme RGB colour scheme	Active contour-based tracking will be the best as computational complexity is low compared to other methods.
[13]	Image Processing	Algorithm for IR image analysis Matlab	Binary model Laplacian model	The algorithm has the ability to detect the percentage of degradation along with the boundary area of the PV module.

It is observed that most of the systems used the ad-hoc networking topology as the topology of the network. The reason for using this is that it is easy to carry out an active communication between the nodes located at random positions of the field.

ZigBee, Bluetooth, GPS and WLAN was the most famous protocol among most of the WSNs for communication as it is a low cost and low battery powered protocol. Most of the systems used Atmega families. ATmega embedded with TinyOS. The reason for using ATmega microcontroller is that is based on RISC architecture and the price of the controller is low.

For the process of object detection and classification, techniques like frame difference, background subtraction and optical flow are used in most the research work. PIR sensor was used to capture the images from the lection and image processing will be applied to analyze the captured images. Some systems have the ability send alert messages to the users if suspicious objects are detected in the area.

Chaithanya and others have found out that the ZigBee protocol is unable to send images as the data rate of the protocol is less [4].

IV. IMPLEMENTATION

After carrying out the critical review and identifying the requirements, the implementation of the proposed system started. The design of the proposed system is provided by figure 2 and the system is developed under two main

components as, development of ML algorithm and website and development of the IoT device.

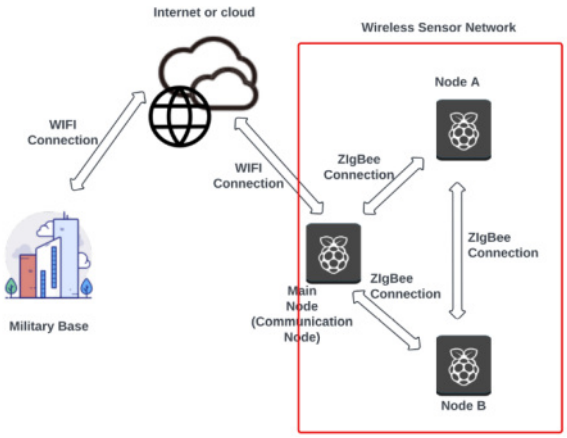

Figure 2. Proposed Design

The proposed system consists of three nodes which are capable to collect video streaming. One an object is detected to one node; it will alert the other nodes using Zigbee Communication. Then the other nodes will also gather the video streaming. The video streaming will be passed to the website and it can be monitored from a remote location.

As the initial approach of implementation, the Machine Learning (ML) model is developed. A CNN is designed to identify humans and non-humans. The initial test accuracy is about 80% and the prediction accuracy is 60%. After training the model, the raspberry pi devices were configured by installing the cameras and the necessary drivers and other software. Tensorflow and OpenCV is also installed and the initially trained model was saved in the pi and it is able to switch on the camera and detect the humans.

Then the implementation of the website is also completed up to 40% and the login is fully completed with all the necessary authentication. The other pages are also developed for about 40% and also it is possible to view the video stream captured by the raspberry pi through the website. Also, it will show whether a human is detected or not.

As further development of the proposed system, it is necessary to implement the security, develop the website and also to improve the accuracy of the ML model to detect humans in a more accurate manner.

V. CONCLUSION

Ten papers were selected and they were divided into two main topics as Military based WSNs and Object tracking and monitoring. Five papers were reviewed under each topic.

Out of the wireless sensor network-based papers, the sensors and the technologies used for each research was identified. ATmega microcontrollers will be the most suitable type of microcontroller to be used for as the controller of the sensor node. ATmega 2560 [4] will be the most suitable microcontroller as it will integrate well with ZigBee protocol. The reason for suggesting the ZigBee protocol is that it is a low cost and a less powered protocol. For the process of deploying nodes in the relevant area, UAVs will be best mechanism to adopt as some places are inaccessible for humans. Zhi-Yan and others propose that LM9628 CMOS sensor as the best senor for image detection as it consumes only less amount of power with improved performance.

Image processing was carried out in several ways and all the authors concluded that HAAR Cascade Classifier Algorithm is the most appropriate method because it has the ability to detect as well as to differentiate both human and non-human objects [10]. Background subtraction will be the most appropriate method to analyze images [11]. CNN based object detection systems use YOLOv3 and CNN algorithms in order to detect the image captured by a camera module or an image sensor node.

After analyzing the results obtained by the systematic literature review, and finding out the most appropriate solution, the system was designed. The proposed system is currently in the process of implementation and the completed and full functional system will be released at the end of the year 2023.

The final output of this proposed system will consist of three nodes which is a collection of a raspberry pi and a camera module. The communication in-between the nodes will be carried out using Zigbee Protocol. The website will be used to stream the obtained video and also to alert the user regarding suspicious detections.

REFERENCES

Z.-Z. J. Zhi-Yan C and M.-Z. H, "An image sensor node for wireless sensor networks," in International Conference on Information Technology: Coding and Computing (ITCC'05), Las vegas, 2005.

T. A. A. A. T and M. B, "A Study on Threats Detection and Tracking Systems for Military Applications using WSNs," International Journal of Computer Applications, vol. 40, no. 15, pp. 12-18, 2012.

Z. T. G. D. Milica P Đ and V. M, "A survey of military applications of wireless sensor networks," in 2012 Mediterranean Conference on Embedded Computing (MECO), Bar, 2012.

C. V. M, "A military surveillance system based on wireless sensor networks with extended coverage life," in 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication (ICGTSPICC), Jalgaon, 2016.

C. V. M and Z. M. J, "Intrusion Monitoring in Military Surveillance Applications using Wireless Sensor Networks

(WSNs) with Deep Learning for Multiple Object Detection and Tracking," in 2021 International Conference on Control, Automation, Power and Signal Processing (CAPS), Jabalpur, 2021.

H. K, "Wireless sensor network using Xbee on Arduino Platform: An experimental study," in 2016 International Conference on Computing Communication Control and automation (ICCUBEA), India, 2016.

A. M and S. A, "Wireless Sensor Network Security in Military Application using Unmanned Vehicle," IOSR Journal of Electronics and Communication Engineering (IOSR-JECE, pp. 51-58, 2014.

S. L. h. S. Sang H L and H. S. L, "Wireless sensor network design for tactical military applications : Remote large-scale environments," in MILCOM 2009 - 2009 IEEE Military Communications Conference, Boston, 2009.

M. W, K.-D. T, K. H and G. B, "Theoretical and Practical aspects of military wireless sensor networks," Journal of Telecommunications and Information Technology, vol. 2, no. 2, pp. 37-45, 2008.

Y. E, A. F. R and A. C, "Developing Human Movement Monitoring System using HAAR Cascade Classifier Algorithm," in 2021 3rd International Symposium on Material and Electrical Engineering Conference (ISMEE), Bandung, 2021.

B. S. S and K. S, "A survey on moving object tracking using image processing," in 2017 11th International Conference on Intelligent Systems and Control (ISCO), Coimbatore, 2017.

h. O and S. S, "Image processing techniques for object tracking in video surveillance- A survey," in 2015 International Conference on Pervasive Computing (ICPC), Pune, 2015.

A. M, G. A, G. D, L. S and Z. R. E, "IR real-time analyses for PV system monitoring by digital image processing techniques," in 2015 International Conference on Event-based Control, Communication, and Signal Processing (EBCCSP), Krakow, 2015.

"IEEE Xplore," [Online]. Available: https://ieeexplore.ieee.org/Xplore/home.jsp. [Accessed 24 November 2022].

"Springer Link," [Online]. Available: https://link.springer.com/. [Accessed 24 November 2022].

"ResearchGate," [Online]. Available: https://www.researchgate.net/. [Accessed 24 November 2022].

"SEMANTIC SCHOLAR," [Online]. Available: https://www.semanticscholar.org/. [Accessed 24 November 2022].

"Google Scholar," [Online]. Available: https://scholar.google.com/. [Accessed 24 November 2022].

"zotero," [Online]. Available: https://www.zotero.org/. [Accessed 24 November 2022].

ACKNOWLEDGMENT

This review was conducted as per the partial fulfillment of Independent Study course module. Gratitude goes to all those who voluntarily supported throughout the study, the academic staff of Faculty of Computing, KDU for the encouragement and guidance for this research work.

AUTHOR BIOGRAPHY/IES

NWAGN Nanayakkara is Currently an undergraduate of Department of Computer Science of Faculty of Computing in General Sir John Kotelawala Defence University. NWAGN Nanayakkara is following a BSC (Hons) in Computer Sceince and is currently working as a Network Engineer Intern in Millenium IT ESP.

Ms WMKS Ilmini is a Lecturer of the Department of Computer Science of Faculty of Computing in General Sir John Kotelawala Defence University, who graduated from University of Sri Jayawardenapura with a BSc (Special) in Computer Science and is currently reading for PhD in the same university.

Ms NT Jayathilake is a ecturer at the Institute of Technology, University of Moratuwa, who graduated from General Sir John Kotelawala Defence University with a Bachelor of science degree in Computer Engineering. She also has recieved a Bachelors degree in Electronics and Automation Technologies from the University of Colombo.